International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 10
***Article Received:** 25 July 2023 **Revised:** 12 September 2023 **Accepted:** 30 October 2023*

Techniques and Approaches of Facial Recognition under Occlusion: A Review

[1]Mahadeo D Narlawar,

Datta Meghe College of Engineering, Airoli, Navi Mumbai, University of Mumbai India, narlawaratul@gmail.com

[2]DR. D. J. Pete,

Datta Meghe College of Engineering, Airoli, Navi Mumbai, University of Mumbai India, dnyandeo.pete@dmce.ac.in

Abstract
A human face is one of the most prominent features used in the process of authenticating technical applications in the domains of security, biometrics, surveillance and forensics. Recognition and detection of facial features has thus become challenging due to problems of occlusion, emotion, image resolution, varying facial expressions and aging. Such attributes tend to have a great impact on the overall performance of a robust facial recognition system. Hence, facial recognition with presence of occlusion triggers to be a hindrance in the natural environment and thereby limits the system model to recognise faces. For this purpose, multiple research authors have inhibited strategies and techniques to address the issues of occlusion. Numerous developments in the field of machine learning and deep learning have constantly evolved with complex architectures that could design the model from scratch and perform image processing to attain maximum efficiency. Such approaches have the potential to accomplish highest state-of-the art accuracy by minimizing error loss. Nevertheless, facial recognition that tends to bypass occlusion is still imperative to limitations for real-world applications. Hence in this review paper, the authors highlight various problems that a facial recognition system with occlusion might face and thereby proposes to analyse various methods of recognition in order to cope with the existing problems. The paper also focuses on extraction approaches thus used present the novelty. The review finally ends, with a mention of future challenges with regards to occluded facial recognition.
Keywords: authentication, extraction, face recognition, machine learning, occlusion

Introduction

With advanced developments in computer vision and image processing, specific target detection has become an important domain in the research study of many authors. A human face being the most prominent feature has become an area of biological study with indispensable amount of work being performed in face recognition. Automatic face detection and recognition has thereby become a preliminary task in computer vision that has contributed in real time applications of face correction, verification and authentication process. Due to this reason, face detection on technical domains have had a great impact in areas of biometrics and forensics. A biometric application of face recognition majorly includes identification of unique fingerprints and user iris patterns. On the other hand, forensic application of face recognition comprises of palm and vein identification that helps to recognise the unique identity of an individual through a non-intrusive manner. In scenarios with large database; the domain of facial recognition has undergone multiple challenges to fulfil the process of image retrieval. Such database includes the application of facial recognition in surveillance operations and passport authentication. The process of facial recognition can however be broken into the following steps:

- Identifying the individual through his facial features thus extracted. This ensures that the features are unique and differs from person to person
- Verifying the facial features thus identified. This ensures that the identified feature is that of an authenticated person

This process is further enhanced with deployment of machine learning and deep learning based techniques which increases the potential of facial recognition by implementing its algorithms. However, despite the usage of such algorithms a satisfactory encounter of face recognition still undergoes hindrance in terms of occlusion. Occlusion in facial recognition process tends to create a barrier for any machine learning algorithm to comprehend the features of a human face. Usage of masks, hat, scarf, sunglasses, varying illuminations, facial expressions hidden through hands, pose variations and low resolutions are different forms of

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 10
Article Received: *25 July 2023* ***Revised:*** *12 September 2023* ***Accepted:*** *30 October 2023*

occlusions that are observed in an image and thereby degrades the detection process. This leads to image destruction in real time; making it difficult for an algorithm to pre-process the face and thereby generate inaccurate results. This is further followed with a decline in image processing strategies that classifies various facial features by extracting face images. Due to reasons as mentioned, occlusion is observed to be an intractable issue that cannot be neglected. Having no prior knowledge with regards to the occluded part creates a barrier for computer vision algorithms. In addition to this; the size and the shape of the image limits the dataset from using respective machine learning techniques. Hence, significant challenges are observed in this domain that arises problems of data missing and exposure due to occlusion. This in some way compromises the classification factor of facial recognition due to occlusions. Figure 1 below illustrates various forms of occlusions that contribute towards a challenging facial recognition process.

Figure 1: Occlusions resulting in improper facial recognitions

The concept of occluded face recognition (OFR) requires a dataset with occlusion free images in it. This dataset is further used as an alternative to create occluded faces. Such a collection of generated occlusions is termed as synthetic occlusions. The entire classification of facial recognition using OFR can broadly be categorised into five scenarios:

- Real occlusions: images obtained from mugshots are usually free from any type of occlusions and are therefore termed as real occlusions. On the other hand mugshot images obtained through occlusions such as scarf or sunglasses are termed as probe occlusions
- Partial occlusions: images obtained from mugshots that are partially visible and partially hidden due to resolution, light, hand gestures etc. is termed as partial occlusions
- Synthetic occlusions: fake images created from real occlusions are termed as synthetic occlusions. This is primarily done to increase the dataset for system implementation
- Rectangular occlusions: images obtained from mugshots that are occluded with black and white rectangles is termed as rectangular occlusions
- Unrelated occlusions: images obtained from mugshots which are non-square in nature and free from illumination occlusions is termed as unrelated occlusions

Hence, an approach used to classify the above mentioned OFR based scenarios is required so that feature extraction of human faces and their respective comparison strategy could be used. Figure 2 below illustrates the categorisation of occlusion strategies used to overcome issues in facial recognition:

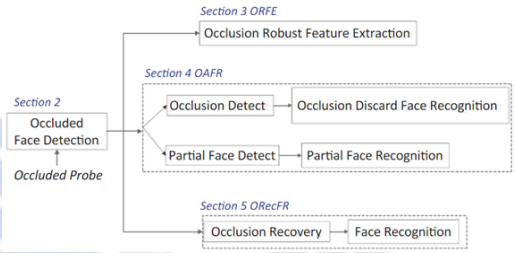

Figure 2: Occlusions resulting in improper facial recognitions

- ORFE: this approach of OFR tends to extract patches of images thus captured from mugshots which acquires less facial feature space and is thereby affected less due to facial occlusions
- OAFR: this approach is specifically aware of the patch area wherein facial occlusions are expected to occur. Due to this, the process of feature extraction focuses only on those facial features which are more likely to qualify for occlusions
- ORecFR: this approach preferably recovers a face free from occlusions by excluding those parts from a mugshot image which won't contribute to facial detection

Therefore it can be concluded that occlusion is one of the primary factors that might be responsible to degrade the overall accuracy of the system model used for facial recognition. Hence, a lot of research work has been conducted to achieve elevated levels of satisfactory results. Apart from occlusion, there are various other factors that tend to affect the overall accuracy of the process. The factors can thus be broadly classified into intrinsic and extrinsic factors. On one hand where intrinsic factors

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 10
Article Received: *25 July 2023* ***Revised:*** *12 September 2023* ***Accepted:*** *30 October 2023*

include aging features of a human; extrinsic factors are more inclined towards resolution and the appearance of the human face.

Hence, a lot of research work has been dedicated in this field of study wherein facial recognitions have been performed on various levels of frontiers. Extensive amount of surveys have been conducted and published which have provided a thorough overview on existing limitations and occlusion challenges. However, there are still two primary reasons for the conduction of the proposed review that demands a new approach on survey being conducted to detect occlusion based facial recognition. The primary reason being the *existence of vast amount of study in this field*. With multiple research strategies it becomes difficult so as to choose an optimised theory for implementation. The secondary reason of the proposed survey; *is the amount of dataset being publically available* for the authors to conduct their research. At times the available datasets lack a sense of fine-tuned parameters which in turn degrades the overall performance of the system model. Therefore, the proposed survey is conducted to provide a systematic categorisation of techniques, algorithms and categories that lead to occlusion based facial detection of human features. In addition to this, the survey also presents a review on recently published papers with innovative strategies addressing occlusion problems.

Occluded Face Detection

This section of the research paper categorises the facial detection into two parts; general face detection and occluded face detection. The process of general face detection is specifically done to detect an occluded face whereas the process of occluded face detection is done to tackle those situations of a facial detection wherein occlusion due to various scenarios occur. The section also briefs on the methods used to detect and design the same.

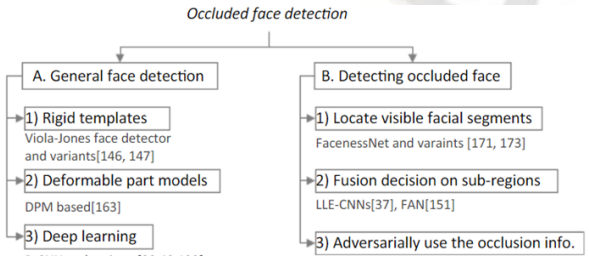

Figure 3: Categorisation of facial detection

General Face Detection

The process of face detection is characterised by detecting the boundary of a face which is captured in a normal environment. This process at times becomes challenging due to multiple factors such as exposure of light, illumination, varying possess etc. In such a scenario, a face can be detected using three approaches:

1. Rigid templates
2. Deformable templates
3. Neural network templates

A commonly used algorithm that subsides in rigid based templates is the Viola-Jones face detector that makes use of machine learning classifiers such as AdaBoost in order to obtain the desired accuracy in the system model. Such cascaded classifier based on rigid templates tends to achieve optimal levels of performance in real time with maximum efficiency [1]. In contrast to the working implementation of a rigid based template; a deformable template achieves much higher levels of accuracy with maximised potential. This in turn follows the disadvantage of utilising high computational complexity while running a system model [2]. Finally, the working implementation of a neural network based template completely differs from the complexities thus involved in the above mentioned two categories. Neural network based face detection classifies various facial features by taking into consideration the alignment of the face with respect to its point of correlation [3]. This third category of face detection approach is further classified into two major branches of CNN:

1. Regions that performs facial recognitions using CNN such as R-CNN [4]
2. Regions that performs facial recognitions using mugshots such as YOLO [5]

Therefore it can be concluded that there are two existential branches of neural networks approach which can be used to detect facial occlusions. However, both the processes are highly time consuming and tends to occupy high levels of complexities. In recent years, various research scholars have explored the implementation of neural networks for face detection using Widerface benchmark [6]. This detection approach eliminates the significant challenges of image resolution, illumination, light intensities and pose variations. The algorithm is thus able to achieve this by using pixel based image resolutions that disseminates between facial features and occlusions.

Detecting Occluded Faces

The process of detecting an occluded face includes, locating those regions of a human face which are hindered by some substance such as a mask, hand gestures, sunglasses etc. In such a scenario, detecting the human face by a machine tends to become a tedious task; since the prominent features

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 10
***Article Received:** 25 July 2023 **Revised:** 12 September 2023 **Accepted:** 30 October 2023*

get veiled. Due to this reason; multiple research scholars have contributed [7] their work in this domain of study wherein they have contributed their work to detect occlusions using various machine learning and deep learning based algorithms. One of the commonly used methods for facial detection includes the utilization of machine learning algorithms such as SVM, KNN and logistic regressions. The performance of such system models is highly affected with respect to the dataset thus used. For this reason; authors in such a scenario, an occluded face can be detected using three approaches:

1. Estimating the full face in order to locate facial segments of the human face which are visible
   The challenges and difficulties related to facial detection are majorly reduced, if the obstacles located on the face are known. Hence, observing such facial features is a mandatory task so that specific attributes of a neural network could be applied for model detection [8]. The methods of CNN used for the same tends to establish a correlation between facial features and human face with respect to the hidden neurons of the system. This correlation is further used to derive attributes of a human face so that its corresponding spatial structure could be determined. For this to occur; CNN networks are specifically trained to identify such attributes and thereby generate response maps of facial features such as that of lips, mouth, eyes etc. Once the facial features are correlated on the map; a scoring mechanism is proposed so that the spatial arrangement can be formed and a degree of face likeliness could be established. After the process of the scoring mechanism, a boundary box is created around the human face thus detect; and is further fetched for precise face locations [9]. The results of the same are obtained through PASCAL Face [52] and AFW [58] wherein the human face thus detected tends to demonstrate and segregate various facial features derived through occlusion. The implementation of the same led to the generation of a highly optimise model with 90 percent recall rate. On the other hand, the process of AFW included the detection of facial features for training which included occlusions within themselves [10]. This extension of PASCAL face with AFW enhances the overall accuracy of the system model and makes it more robust in nature. Additionally, due to the involvement of CNN as the base neural networking model; the presence of hidden layers and neurons generate more compelling results. The execution of PASCAL face and AFW have however occurred on a Widerface dataset [11] so that face occlusions with multiple challenges such as those of pose variations, image resolutions and illuminations could be identified. However, the usage of the Widerface dataset eliminates the need of data augmentation and thereby provides multiple variations in occlusion based facial recognition wherein multiple attributes of the face are labelled using CNN. Hence, the usage of neural networks in the same provides a system model with higher levels of efficiency.
2. Fusing the obtained facial segments of the human face to create an impact on the occlusion thus generated
   In a research paper presented by authors in [12], they proposed the detection of facial images by obtaining segments of facial features that were captured using the camera from mobile devices. The obtained images were further authenticated using machine learning based classifiers such as AdaBoost wherein a specific pattern of images were formed and were further segmented into 14 sub-sections. The sub-sections thus created helped to form clusters of facial images. In the later stage, a full face and a partial face segmentation was achieved using the Widerface dataset [13]. The resulting dataset allowed the process of authentication to be carried out with a pre-defined architecture based on occlusion. The same work was further extended by authors in [14] wherein they conducted a similar experiment using CNN as the base network. The author however used the MAFA dataset [25] to achieve the same and further extracted facial features using masked face detection techniques. The process was capable to extract only the relevant facial features by forming a facial boundary around the face regions. The regions were further embedded using linear regression and a high dimensionality feature reduction was thereby performed. In the end, a classification model based on CNN was used false positive rates were identified. The proposed model thereby helped to detect facial images based on occlusions caused dude to sunglasses, hats, eye wears etc.
3. Using the concepts of occlusion in an adversarial way
   Apart from the above mentioned methods wherein an estimation of facial segments is performed along

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 10
***Article Received:** 25 July 2023 **Revised:** 12 September 2023 **Accepted:** 30 October 2023*

with fusing the sub-sections of facial segments; is an implementation of a third way wherein all the adverse effects of an occlusion are discarded due to grid loss approach [15]. This approach is used to combine the functioning of a CNN along with spatial occlusions so that a subset of detectors could be formed and predictions can be thus made. In a research work proposed by authors in [16], they used the approach of grid loss to reduce the error rate thus caused due to partial occlusions. The hindrance in the image thus generated due to occlusions was adversely removed using Adversarial Occlusion Facial Detection (AOFD). This led to the creation of boundaries and segments around the human faces which was further integrated using masking techniques. The mask generator was responsible to create occlusion situations and thereby segregate the distinctive parts of the image in an adversarial way. In addition to segmentation caused due to occlusion; the performance of the system model was enhanced due to masking and limitations of an image such as varying poses, illumination etc. were discarded.

Related Works

In a research work proposed by authors Zhang.B.Lahaw et al. in [17] they introduced a method that could identify facial recognitions using algorithms such as linear discriminant analysis (LDA) and principal component analysis (PCA). The method was further enhanced using 3 machine learning based algorithms namely; SVM, KNN and logistic regression. The database used by the author was the MAFA dataset that comprised of 400 human faces that were subjected to 40 attributes. The attributes included varying characteristics of natural environment such as light, illumination etc. The images were also expected to include occlusions comprising of human faces that were covered with sunglasses, hats, masks and scarfs. All the 400 images of the human face were taken from 10 different angles with respect to varying shades of light. The images were further converted to grayscale resolution and resized to 112 x 92 pixels. The method thus adopted generated an accuracy of 96 percent through the implementation of LDA combined with SVM. In another work proposed by authors N. Sabri et al. in [18] they compared the working implementation of four machine learning based algorithms and further developed a hybrid model using Multi-Layer Perceptron (MLP). The implementation of classifiers thus included SVM, KNN, Naïve Bayes and Logistic Regression. The classifiers were used to create a boundary around the human face and therefore seclude them with occlusions so that optimised levels of accuracy could thus be obtained. For this purpose, the distinctive measure with respect to facial geometry was thus calculated. The mathematical calculation performed led to the elimination of irrelevant features from the human face. Throughout the experimentation, it was observed that the performance generation of Naïve Bayes created high levels of accuracy and produced a recall rate of 93.16 percent.

Facial discovery using detection approaches of image segmentation was used by authors in [19] wherein they proposed the implementation of Support vector machine combined with the conceptual working of LDA. The usage of SVM assisted to detect the facial features from the dataset and further segregate them on the basis of occlusions obtained. The facial segmentation also involved creating a rectangular boundary box to discover faces. In addition to the execution of machine learning algorithms and LDA; the author also used gradient histograms. Such histograms were generated using OpenCV library in Python. The final result of the overall model was therefore judged on the basis of efficiency generated. The combined usage of SVM as a machine learning classifier along with LDA and histograms led to the generation of 92.68 percent efficiency.

A MAFA dataset was used by authors in [20] wherein an enhanced adaptive approach was used for facial recognition. The author also used the execution of Linear Descriptive Analysis (LDA) along with Multi-Layer Perceptron (MLP). The research study thus presented by the author followed the concept of using neural networks to detect the same. The work was enhanced using neurons and multiple hidden layers and thereby led to the generation of increased accuracy. Since MAFA dataset was used; the implementation was later combined with machine learning based classifier of SVM and KNN. On pre-processing the images using OpenCV; the features of the face were thereby extracted and spatial recognition was established. The obtained features were later combined with the the respective attributed obtained from the dataset.

In another work by authors Sujata G. Bhele and V.H. Mankar in [21] provided a significant survey in developments being performed in the domain of facial recognition systems. The author provided a detailed overview on multiple research works and finally compared them. It was observed that majority of the datasets were implemented on the MAFA dataset and the Widerface dataset that provided large number of image features based on occlusions. The acquired dataset was then pre-processed for feature extraction using spatial recognition techniques and a hybrid model was thus developed using machine learning classifiers. The survey also compared the existing

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 10
***Article Received:** 25 July 2023 **Revised:** 12 September 2023 **Accepted:** 30 October 2023*

works with deep learning algorithms wherein multiple research scholars worked on the conceptual theory of CNN and neural networks that enhanced the overall system of the architecture thus developed. Algorithms such as CNN, RNN and ANN were heavily used and stacking algorithms were created to generate higher levels of accuracy. The survey thus presented by the author covered majority of the recent works being done in the same field of study. It was also observed that the occlusions in the researches included criteria's of facial recognition and occlusions which included lighting and varying illuminations. In addition to the usage of algorithms and machine learning algorithms; the authors also conducted his survey based on LDA and PCA approaches. This usage of principal component analysis (PCA) is a feature algorithm specifically dedicated to extract facial features from a human face and thereby discard the rest by using a boundary box. However, its working implementation is not evaluated on the basis of the dataset thus acquired; but rather evaluated on the attributes gathered from the dataset. Individual attributes of a human face is collected and its intensity is calculated to generate accuracy and recall factors. The process is therefore called; empirical evaluation and is generally performed in the training phase. The extracted attributes are later compared and applied to the image features using PCA. Hence, PCA is considered to be a method used for data analysis in a multidimensional hyperspace with no prior information of the input data structure.

In another work by authors in [22] they analysed a pattern in facial detection wherein numerous images from the dataset were obtained and analysed upon to extract the features. One of the challenges faced by the author was to identify the static features and segregate them from the occlusions thus present. For this to occur; the author pre-processed the image, modified it and further converted it into grayscale. The image was also resized in the process. The dataset used for the same was however obtained from Widerface and comprised of 400 occluded faces. Since occlusion was present; the images were not clearly visible and led to the generation of obscured images with improper lighting. The author further proposed the implementation of Viola Jones algorithm along with PCA. A hybrid model was thus combined and developed to detect facial recognition with occlusions. In addition to the hybrid model; the author also implemented three machine learning algorithms namely; SVM, KNN and logistic regression. An Eigen value was calculated through Viola Jones algorithm and mathematical calculations were thus performed to achieve recall factors. The proposed study however generated an accuracy of 90 percent.

The table below mentions some of the research work performed by multiple research scholars:

Table 1: Comparative Analysis

Author	Database	Technique	Application	GIST	Accuracy
Abdol hossein Fathi [23]	MAFA	Facial segmentation	Histogram Orientation	PCA was used and Eigen face values were calculated. Variations in image resolution was also performed	98 percent
Z.H.D. Eng [24]	MAFA	Spatial extraction	Feature processing	Virtual views resulting from occlusions led to deterioration of model efficeincy	97.81 percent
Ayan Seal [25]	YALE	Image processing using fusion algorithm	Machine learning classifiers	Factors of varying illuminations were not considered; thereby resulting in higher time complexity	92.36 percent
Abdelghafour Abbad [26]	CURTIN	Local discriminator with colour fusion	Principal component analysis (PCA)	Partial occlusion was focused upon and cross resolution factors	88.76 percent

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 10
***Article Received:** 25 July 2023 **Revised:** 12 September 2023 **Accepted:** 30 October 2023*

				were neglected	
Brahim Aksasse [27]	WiderFace	Geometric descriptors with grayscale strategy	Principal component analysis (PCA)	Supervised learning approach that focused on varying pose variations caused due to occlusion	80.23 percent
Ge Wen et.al [28]	CURTIN	Shape matching based on face descriptor	Adversarial networks	Feature based approach was used to detect occlusions caused due to distortion	94.23 percent

Performance Evaluation of Occluded Face Detection

Multiple datasets are used for face detections that are based on occlusions. Commonly used datasets includes MAFA, AFW, PASCAL and WiderFace. The acceptance of MAFA as the dataset is developed with the intention of resolving occlusions using masking techniques. The database used in [24] comprises of 60 masking layers used on 400 occluded facial images. In addition to the masking layers; 35 attributes were extracted from the dataset and 80 annotations were executed to resize the images from RGB to grayscale. Hence, a reduction in the pixel size was observed wherein 32 x 32 resolution of the image was obtained. An example of occluded face images is illustrated in figure 1 which is captured with hand gestures occurring over the face, or the usage of sunglasses by the people. In comparison to all the datasets thus used; the execution of MAFA overcomes all the respective challenges faced including to that of varying possess and illumination. The performance and the accuracies thus achieved by different system models are mentioned in table 1. However, this section of the thesis highlights the performance evaluation of models based on the occlusions that have helped to detect facial features using ORFE, OAFR and ORecFR.

Table 2: Existing benchmarks

Author	Dataset	Occlusions	Approach	Performance
He, L., et al. [29]	MAFA	Scarf, sunglasses	ORFE	93.68 percent
L., et al. [30]	WiderFace	Hat, scarf	ORecFR	90.78 percent
Chen, Y., Song, L. [31]	PASCAL	Scarf, masks, sunglasses	ORFE	91.23 percent
Zhang, J., et al. [32]	MAFA	Scarf, sunglasses	OAFR	94.28 percent
Lahasan, B. [33]	AFW	Scarf, sunglasses	ORecFR	92.31 percent

Conclusions

The primary aim of the study thus presented was to conduct a thorough survey on the existing techniques, strategies and approaches used to detect various forms of facial detection methods that are based and occurred through occlusion. Hence, the paper represents a review on occlusion based facial detection, its approaches and the existing work being analysed by multiple research scholars. In addition to this; a focus was also made on machine learning and deep learning based techniques, classifiers and algorithms; wherein the importance of respective algorithms was pondered upon. Apart from this; the commonly used datasets for the detection of the same was also mentioned. It is worthy to note here that majority of the datasets used by the research scholars included the MAFA, WiderFace, AFW and the PASACAL dataset. The MAFA dataset proves to overcome multiple challenges that might occur during image download from the repository and is therefore used. A comparative analysis of multiple works has also been illustrated along with a differentiation factor being hindered upon. The differentiation factor thus used was based on the levels of accuracies obtained along with performance evaluation factors of recall and precision. The review finally comes to an end with conclusions about the same being made followed by future challenges and references.

Future Challenges

One of the major challenges as observed is the presence of unconstrained factors that tends to make the entire process of facial recognition a tedious process. Unlike the working

detection of occlusions; unconstrained methods fails to identify occluded faces. Hence, the notion of using a MAFA dataset also eliminates in such a scenario. Apart from unconstrained factors, other measures such as age gap and images with low resolution creates a hindrance in identifying facial detection based occlusions. Therefore in such a scenario, developing a system model based on machine learning and deep learning classifiers does not tends to generate high levels of efficiency. The survey conducted reveals that majority of the identification process has been done using machine learning classifiers and neural networks. However, this section of the review paper suggests ways to overcome existing limitations and thereby move towards future challenges:

- Augmentation techniques: adoption of augmentation techniques lead to the generation of more number of discriminative features that helps to detect multiple forms of occlusions existing in the image. With template based strategies as previously mentioned; images can be properly aligned and facial landmarks can eventually be pointed. In addition to augmentation techniques; usage of adversarial networks can also be done to differentiate between occlusion faces and occluded free faces
- Novelty in detection techniques: adapting to better datasets and usage of proper occlusion templates is an optimised way to create novelty in the existing techniques that might result into generation of better accuracies. By using patch based factorisation, feature extraction techniques, LDA and PCA; a unified framework of face recognition system can thereby be successfully built

References

[1] Paul, V., Jones, M.: Rapid object detection using a boosted cascade of simple features. In: Proceedings of the 2001 IEEE Computer Society Conference on Computer Vision and Pattern Recognition, 1, I–I. IEEE(2001)

[2] Yang, B., et al.: Aggregate channel features for multi-view face detection. In: IEEE International Joint Conference on Biometrics, 1–8.IEEE (2014)

[3] Bai, Y., et al.: Finding tiny faces in the wild with generative adversarial network. In: Proceedings of the IEEE Conference On Computer Vision and Pattern Recognition, 21–30 (2018)

[4] Girshick, R., et al.: Rich feature hierarchies for accurate object detection and semantic segmentation. In: Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition, 580–587 (2014)

[5] Joseph, R., et al.: You only look once: real-time object detection. In: Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition, 779–788 (2016)

[6] Dagnes, N., et al.: Occlusion detection and restoration techniques for3d face recognition: a literature review. Mach. Vis. Appl. 29, 789–813(2018)

[7] Dagnes, N., et al.: Occlusion detection and restoration techniques for3d face recognition: a literature review. Mach. Vis. Appl. 29, 789–813(2018)

[8] Best-Rowden, L., Anil, K.J.: Longitudinal study of automatic face recognition. IEEE Trans. Pattern Anal. Mach. Intell. 40(1), 148–162(2018)

[9] Wang, H., et al.: Cosface: large margin cosine loss for deep face recognition. In: Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition, 5265–5274 (2018)

[10] Cao, Q., et al.: Vggface2: a dataset for recognising faces across pose and age. In: 2018 13th IEEE International Conference on Automatic Face& Gesture Recognition (FG 2018), 67–74. IEEE (2018)

[11] Muhtahir, O.O., Hancke, G.P., Kapileswar, N.: Evaluating the effect of occlusion in face recognition systems. In: 2017 IEEE AFRICON,1547–1551. IEEE (2017)

[12] Trigueros, D.S., Meng, L., Hartnett, M.: Face recognition: from traditional to deep learning methods. arXiv preprint arXiv:1811.00116,(2018)

[13] Lahasan, B., Lut□, S.L., San-Segundo, R.: a survey on techniques to handle face recognition challenges: occlusion, single sample per subject and expression. Artif. Intell. Rev. 52, 949–979 (2019)

[14] Maze, B., et al.: Iarpa janus benchmark-c: face dataset and protocol. In:International Conference on Biometrics (ICB), 158–165. IEEE (2018)

[15] Sun, X., Wu, P., Hoi, S.C.H.: Face detection using deep learning: an improved faster rcnn approach. Neurocomputing, 299, 42–50 (2018)

[16] Bai, Y., et al.: Finding tiny faces in the wild with generative adversarial network. In: Proceedings of the IEEE Conference On Computer Vision and Pattern Recognition, 21–30 (2018)

[17] Zhang, Z., et al.: Robust face detection via learning small faces on hard images. In: The IEEE Winter Conference on Applications of Computer Vision, 1361–1370 (2020)

[18] N. Sabri et al., "A Comparison of Face Detection Classifier using Facial Geometry Distance Measure,"

2018 9th IEEE Control and System Graduate Research Colloquium (ICSGRC), Shah Alam, Malaysia, 2018, pp. 116-120.doi: 10.1109/ICSGRC.2018.8657592

[19] A. Adouani, W. M. Ben Henia and Z. Lachiri, "Comparison of Haarlike, HOG and LBP approaches for face detection in video sequences," 2019 16th International Multi-Conference on Systems, Signals & Devices (SSD), Istanbul, Turkey, 2019, pp. 266-271

[20] J. Fan, Q. Ye and N. Ye, "Enhanced Adaptive Locality Preserving Projections for Face Recognition," 2017 4th IAPR Asian Conference on Pattern Recognition (ACPR), Nanjing, 2017, pp. 594-598

[21] Sujata G. Bhele and V.H. Mankar, A Review Paper on Face Recognition Techniques,in The International Journal of Advanced Research in Computer Engineering and Technology (IJARCET) vol 1, Issue 8, October 2012

[22] H. S. Karthik and J. Manikandan, "Evaluation of relevance vector machine classifier for a real-time face recognition system," 2017 IEEE International Conference on Consumer Electronics-Asia (ICCE-Asia), Bangalore,2017, pp. 26-30

[23] Abdol hossein Fathi, Pendar Alirezazadeh, Fardin Abdali-Mohammadi A new Global-Gabor-Zernike feature descriptor and its application to face recognition Journal of Visual Communication and Image Representation, 38 (2016), pp. 65-72

[24] Z.H.D. Eng, Y.Y. Yick, Y Guo, H. Xu, M. Reiner, T.J. Cham, S.H.A. Chen 3D faces are recognized more accurately and faster than 2D faces, but with similar inversion effects Vision Research, 138 (2017), pp. 78-85

[25] Ayan Seal, Bhattacharjee Bhattacharjee, Mita Nasipuri "Human face recognition using random forest based fusion of à-trous wavelet transform coefficients from thermal and visible images AEU-International Journal of Electronics and Communications, 70 (8) (2016), pp. 1041-1049

[26] Abdelghafour Abbad, Khalid Abbad, Hamid Tairi 3D face recognition: Multi-scale strategy based on geometric and local descriptors Computers & Electrical Engineering (2017)

[27] Brahim Aksasse, Ouanan Ouanan, Mohammed Ouanan Novel approach to pose invariant face recognition Procedia Computer Science, 110 (2017), pp. 434-439

[28] Ge Wen, Chen Chen, Cai Cai, Xiaofei He Improving face recognition with domain adaptation Neurocomputing, 287 (2018), pp. 45-51

[29] He, L., et al.: Dynamic feature matching for partial face recognition.IEEE Trans. Image Process. 28(2), 791–802 (2019)

[30] L., et al.: Occlusion robust face recognition based on masklearning with pairwise differential siamese network. arXiv preprintarXiv:1908.06290 (2019)

[31] Chen, Y., Song, L., He, R.: Masquer hunter: adversarial occlusion-awareface detection. arXiv preprint arXiv:1709.05188 (2017)

[32] Zhang, J., et al.: Feature agglomeration networks for single stage facedetection. Neurocomputing. 380, 180–189 (2020)

[33] Lahasan, B., Lut□, S.L., San-Segundo, R.: a survey on techniques tohandle face recognition challenges: occlusion, single sample per subjectand expression. Artif. Intell. Rev. 52, 949–979 (2019)